THE DUAL CHAMBER

CONTROLLABLE SOLID ROCKET

(DCCSR)

NORTHROP CAROLINA

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CONTROLLABLE SOLID ROCKET

(DCCSR)

Presented by

NORTHROP CAROLINA

A Subsidiary of NORTHROP CORPORATION

Asheville, North Carolina

UNIQUE CAPABILITIES

Northrop Carolina's Dual Chamber Controllable Solid Rocket (DCCSR) is completely "command" controllable in both stop-restart and thrust modulation modes of operation, which heretofore had been available only in liquids. The dual chamber controllable solid incorporates all the inherent advantages of solid rockets, i.e., simplicity, reliability, lower development and production costs, long term field storage with minimum (or no) maintenance required, and design flexibility, into one unique propulsion system.

The dual chamber controllable solid rocket motor is manufactured in precisely the same way as a conventional solid. All the control capability is provided by the interchamber valve. It is not necessary to preprogram either the thrust level, thrust pulse duration, off time between thrust pulses, or the thrust modulation cycle. These parameters may in fact be commanded during flight as a function of some measured mission parameter such as ΔV or a point in space.

Another unique aspect of the Dual Chamber Controllable Solid Rocket's flexibility is the Post Boost Propulsion System (PBPS) mode of operation. The Post Boost Propulsion System requires continuous attitude control with "on-command" axial thrust pulses for ΔV addition. This is accomplished in the Dual Chamber Controllable Solid Rocket by igniting the gas generator of the dual chamber at the beginning of the mission and allowing it to operate continuously. The thrust motor is operated in an "on-command" pulse mode by actuating a simple on-off valve which controls flow of gas generator gases to the thrust motor. The gas generator gases are bled continuously to the Attitude Control System.

UNIQUE CAPABILITIES

- THROTTLEABLE
- STOP-RESTART
- DOES NOT REQUIRE PREPROGRAMMING
- STOP-RESTART WITH CONTINUOUS ATTITUDE CONTROL GAS SUPPLY
- STOP-RESTART, THROTTLING, AND CONTINUOUS ATTITUDE IN SINGLE UNIT
- COMPLETE IN FLIGHT COMMAND CONTROLLABILITY
- PACKAGING FLEXIBILITY

PERFORMANCE CAPABILITIES

The attainable specific impulse of the Dual Chamber Controllable Solid Rocket concept is comparable to current state-of-the-art of conventional composite solid propellants. Both non-metalized and metalized compositions have been successfully used in stop-restart and throttling static tests.

Motor sizes ranging from one to one thousand pounds of propellant have been manufactured and static tested to prove the scalability of the DCCSR.

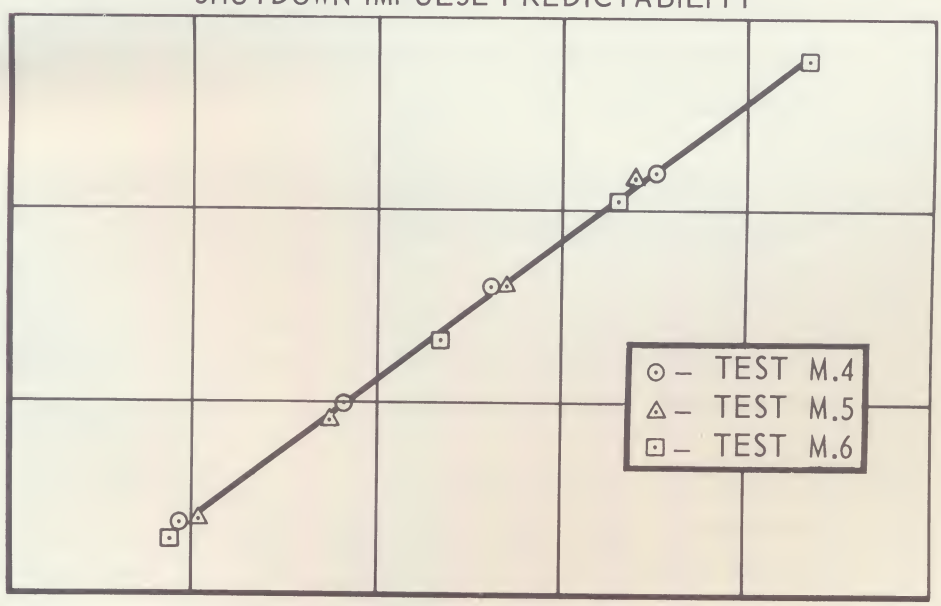
Designs have been made for total motor weights of 300-1000 pounds with mass fractions of up to 0.85 in the basic stop-restart configuration. Mass fractions of 0.80 are attainable in a Post Boost Propulsion System Configuration where the attitude control ducting, valves and nozzles are included.

In system applications where precise positions and velocity increment additions are critical, the response characteristics of the attitude control valves and the shutdown impulse of the primary thrust are extremely important. Ten millisecond response rates are current state-of-the-art for warm (2200°F) gas attitude control valves. The test data presented on shutdown impulse predictability was taken from three different motor tests in which each motor was conducted through four stop-restart cycles.

PERFORMANCE CAPABILITIES

- CURRENT SOLIDS STATE-OF-THE-ART SPECIFIC IMPULSE
- MOTOR SCALED FROM 1 TO 1000 POUNDS OF PROPELLANT
- 0.85 MASS FRACTION IN BASIC SYSTEM
- 0.80 MASS FRACTION IN POST BOOST PROPULSION SYSTEM APPLICATION
- 10 MILLISECOND ATTITUDE CONTROL RESPONSE
- PREDICTABLE SHUTDOWN IMPULSE CHARACTERISTICS

SHUTDOWN IMPULSE PREDICTABILITY



CONCEPT

Northrop Carolina's Dual Chamber Controllable Solid Rocket (DCCSR) is completely COMMAND controllable in both stop-restart and thrust modulation modes of operation, which heretofore had been available only in liquids.

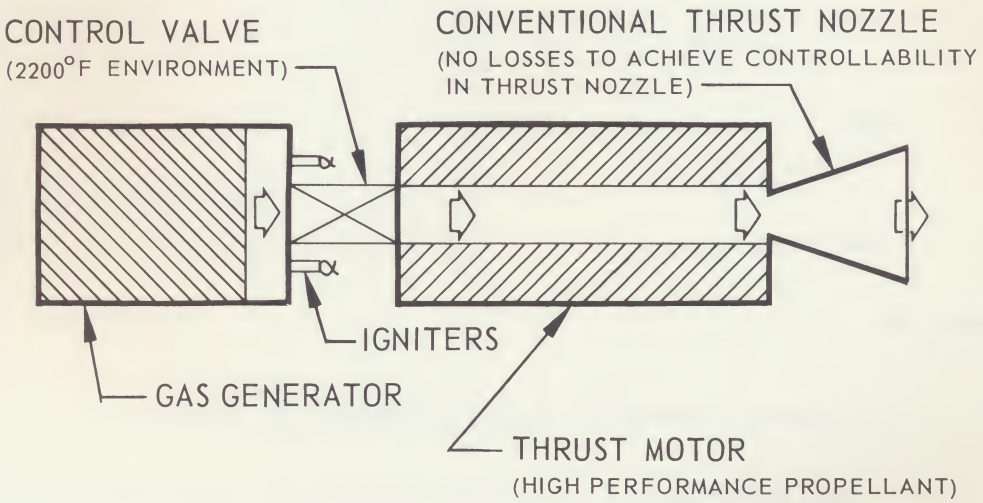
The DCCSR utilizes a forward (gas generator) chamber, loaded with a non-metalized, low flame temperature propellant and an aft (thrust) chamber loaded with a high performance propellant. The two chambers are separated by a control valve for command termination and/or modulation of the low flame temperature gas generator mass flow. A conventional high performance nozzle generates thrust from the aft motor mass flow. Multiple igniters, for the gas generator, provide command restart capability.

In its basic mode of operation, the DCCSR provides COMMAND stop-restart and a wide range of thrust modulation. In the operational mode required for Post Boost Propulsion Systems (PBPS), such as is utilized on the Air Force's Reentry Measurement Program (RMP), the Dual Chamber Controllable Solid Rocket provides gases for continuous attitude control of the maneuvering bus as well as "on-command" axial thrust.

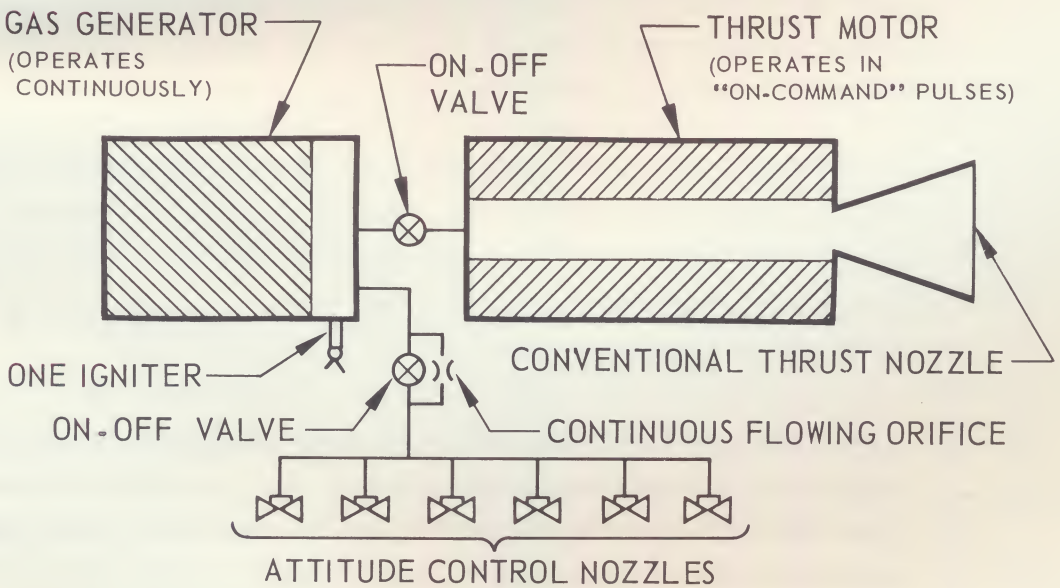
The Reentry Measurement Program flights will employ the first propulsion system flown, either liquid or solid, in a Post Boost Propulsion System application.

CONCEPT

BASIC STOP RESTART / THROTTLING MODE



POST BOOST PROPULSION SYSTEM (PBPS) MODE



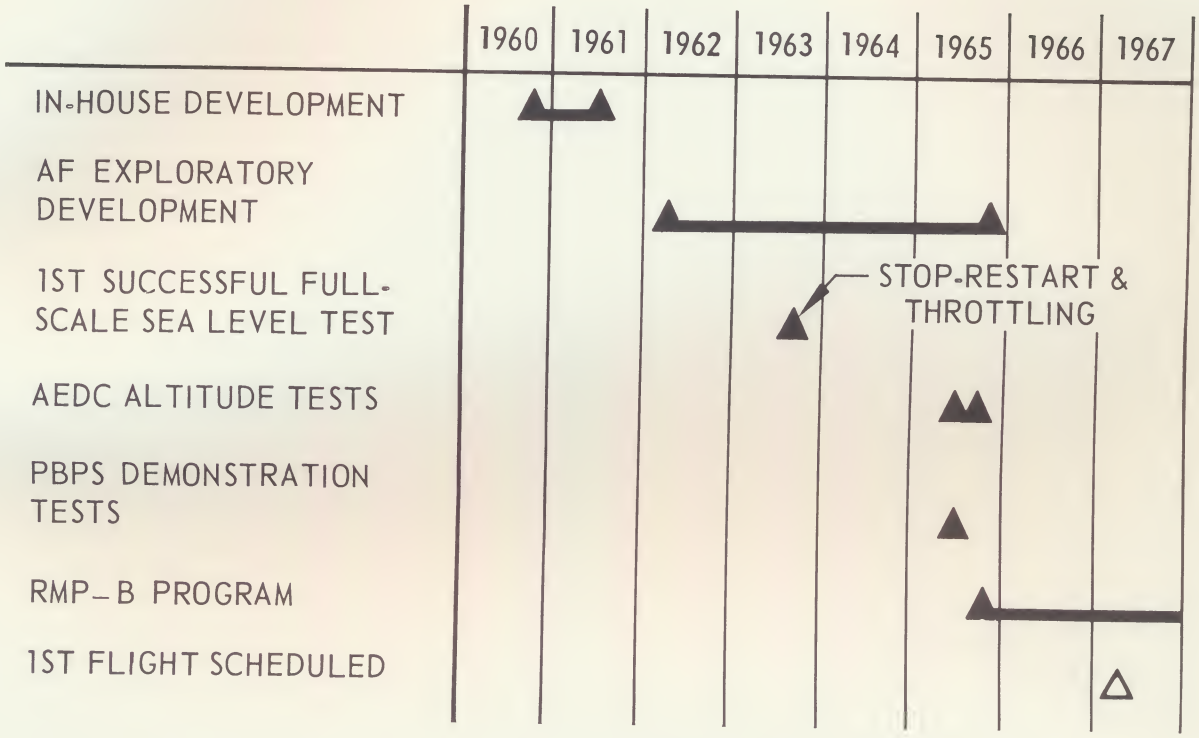
DEVELOPMENT MILESTONES & HISTORY

The Dual Chamber Controllable Solid Rocket is the nation's first operating, all-solid, controllable rocket motor. Three years of exploratory development, of this unique solid propulsion system, were sponsored by the Air Force System Command's Rocket Propulsion Laboratory at Edwards Air Force Base, California. In this program, the Dual Chamber Controllable Solid Rocket underwent hundreds of test firings which proved its wide throttling range and its capability for multiple stops and restarts, both at sea-level and in simulated space environment.

In simulated altitude tests conducted at the Ordnance Aerophysics Laboratory, Daingerfield, Texas in July 1965 and at the Arnold Engineering Development Center, Tullahoma, Tennessee in December 1965, DCCSR motors were successfully test fired through TEN stop-restart operational cycles and the thrust modulated over a TEN-TO-ONE range.

In July 1965, the operational mode required for Post Boost Propulsion Systems was demonstrated in sea level static test which led to initiation of the RMP-B, to develop and deliver Dual Chamber Controllable Solid Rockets for reentry measurement flight tests.

DEVELOPMENT MILESTONES



DEVELOPMENT HISTORY

- TEST SUMMARY:

MOTOR SIZE	PROPELLANT WEIGHT (LB)	FIRINGS
2 IN.	1	104
6 IN.	30	160
18 IN.	200	2
13 IN.	300	9
18 IN.	300	8
16 IN.	400	5
22 IN.	944	9 (RMP–B)
		297 TOTAL

- DEMONSTRATED RESULTS:
  - SCALABILITY PROVEN, FROM 1 TO 1000 POUNDS OF PROPELLANT
  - REPRODUCIBLE IGNITION, TERMINATION, SHUTDOWN IMPULSE
  - MULTIPLE STOP-RESTARTS (10) AND THROTTLING (10/1 RANGE) IN 10 FULL-SCALE MOTORS AT SEA LEVEL AND ALTITUDE
  - AXIAL THRUST PULSING WITH CONTINUOUS ATTITUDE CONTROL

APPLICATIONS

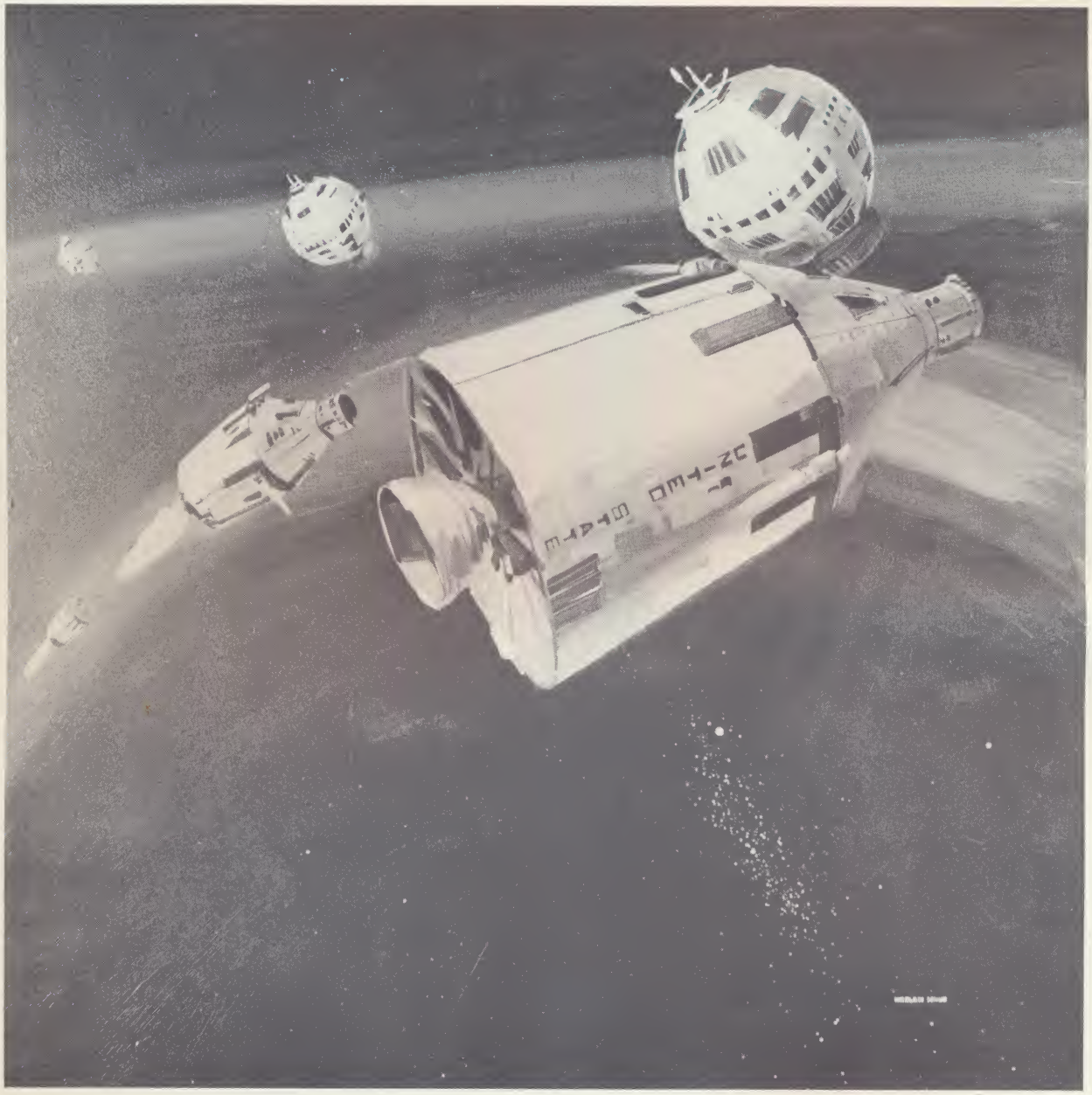
The Dual Chamber Controllable Solid Rocket is applicable to those systems which require thrust pulses, throttling, and attitude control whether these are required all together or separately.

The chart lists some of the more prominent applications known today and artist renderings of four of these.

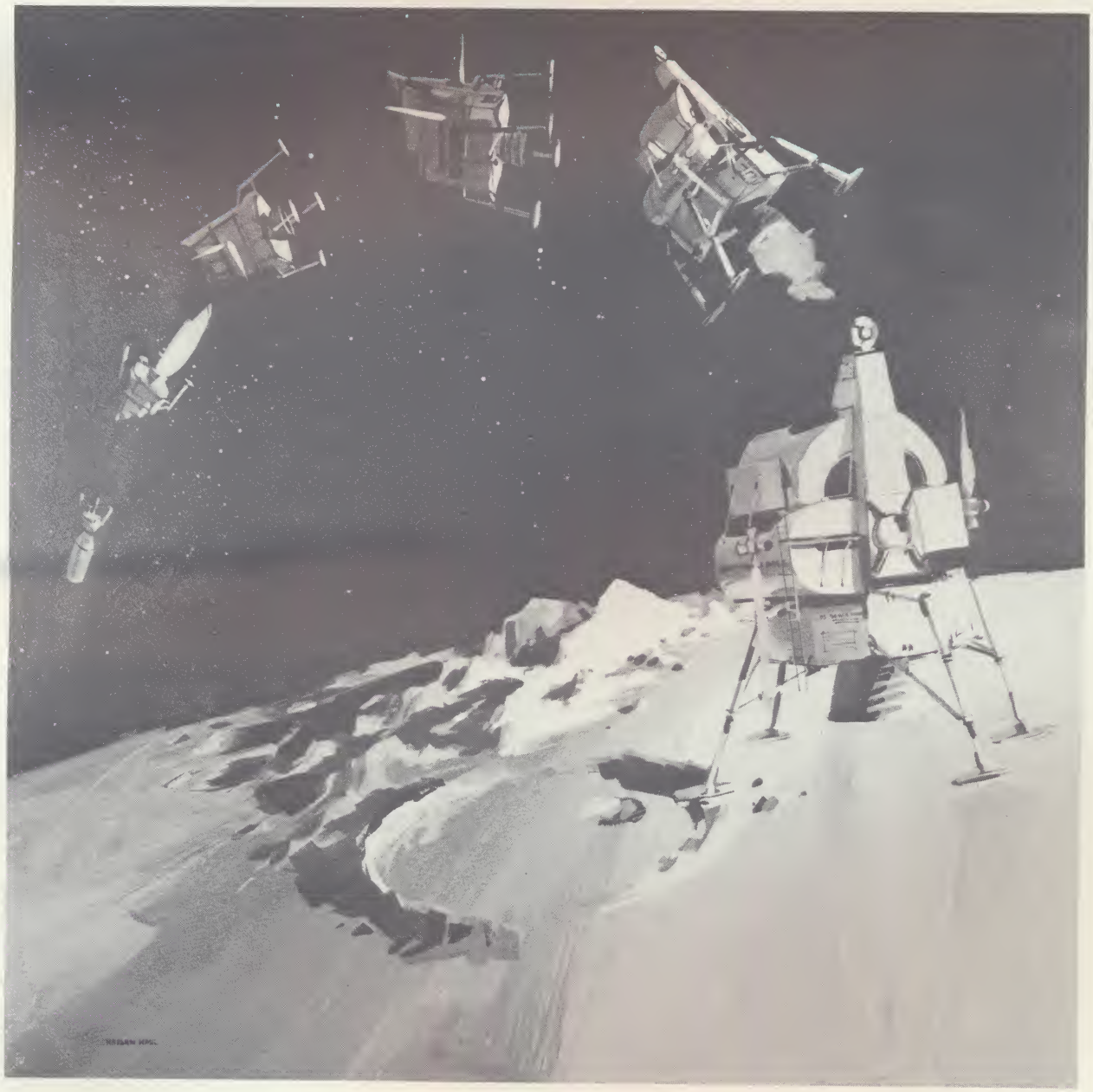
APPLICATIONS

- SIMULTANEOUS ATTITUDE CONTROL/PULSED BOOST
- ORBIT INJECTION AND INTERCHANGE
- BOOST VERNIER
- SPACECRAFT OR REENTRY VEHICLE MANEUVERING
- SPACECRAFT RETRO LANDING SYSTEM
- VARIABLE THRUST CONTROL FOR TACTICAL MISSILES
- THRUST VECTOR CONTROL ON BOOSTERS

SPACE RENDEZVOUS



LUNAR LANDING



AIRFORCE MISSION

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